

UK/US Naval Interoperability Collaborative Research

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Abstract

This paper outlines a collaborative program of work being carried out under an agreement between the US and the UK which started in January 2000 and is due to continue for four years. The research is looking at the operational problems of coalition force interoperability initial from a naval perspective at the command and combat system level but then moving to a wider domain to cover both land and air participation. Details are given of why the research is necessary, the objectives and the approach being adopted.

1. Introduction

Successful deployment of interoperable systems is essential in the emerging era of network-centric warfare. Increasing reliance on joint and coalition forces to achieve naval objectives has made more urgent the need for operational integration of diverse naval combat systems. The rapid introduction of Commercial-Off-The-Shelf (COTS) technology aboard ships, particularly information technology, has yielded many benefits, but has resulted in new problems as well. There is a pressing need to address some of these issues before the operational units are deployed into a hostile environment, at which time the lack of effective interoperability may adversely effect the ability of the participating units to work together. In this paper a collaborative research programme is outlined giving details of the overall objectives and the initial progress made so far towards achieving those.

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2. Objectives

Under the auspices of the US-UK Memorandum of Understanding (MOU) concerning Technical Research and Development Projects (TRDP), a new collaboration programme on Naval Combat System Interoperability (NCSI) has been negotiated to evaluate how naval combat systems can be integrated for effective coalition force operations at platform and task force level in the context of the performance constraints associated with technical aspects such as architectural choices for such systems and the command issues such as interpretation of information.

It is the intent of this collaboration to expand the capability of both the UK and US defence communities to evaluate candidate technologies and architectures to improve the effectiveness of such operations. To that end, a set of UK test-beds will be integrated with each other and with a similar set of US test-beds to permit testing of greater scope. The first of these sites will represent the various naval domains (i.e. surface and subsurface) and, initially, the experimentation will address command level information exchange between the US and UK combat systems. The investigation will then move on to address the feasibility of task force integration at the sensor data level aiming at the final objective of allowing full naval task force data fusion to be carried out. Later stages will be expanded to include both the land and air elements of a combined task force.

The first stage of the project is being conducted as a joint effort specifically addressing information system architecture support for interoperability. The expected payoffs include:

- a wide-area network-based experimentation and interoperability capability that encompasses surface and subsurface combat systems for both the US and UK navies and is capable of addressing coalition force issues,
- understanding of the technical constraints and necessary architectural standards for assuring effective interoperability of naval combat systems,
- a modified design process for combat systems that reflects architecture-based development and standards-based architecture.

It will in the longer term provide a facility which can be employed to test out the coalition force capabilities in all areas of command, weapon and sensors fits before they are deployed in future platforms.

3. Scope of the Collaboration

The following work will be carried out under the agreement. It will be divided into several phases each of which will culminate with the generation of a demonstration to be carried out jointly between the two participants to show the achievements of the research work.

Phase I. Design, implementation and interconnection of NUWC and DERA Portsmouth Open Systems Test beds to be utilised for a limited demonstration of COTS/OSA technology. This will allow for a one to one link and provide proof of

concept for the future experimentation at the hardware level . It will also set the foundation for a common sim/stim capability to drive the experimentation and cover the exchange of basic picture information. The major activities are firstly to establish the link by the passing of tactical picture data and associated scenario information through the existing CORBA and DIS links and the sharing of control by both sides

Phase II. Design, implementation and interconnection of OSA test beds at NUWC, NSWCDD, DERA Portsmouth, and DERA Winfrith to support an expanded demonstration of US NSSN and SC21 OSA technologies and UK CSTDF/CSI COTS/OSA technologies. This will expand on the levels of information which will be transferred between the systems and form the basis for the investigation of sensor information exchange which will enable additional data to be passed using CORBA and HLA or DIS.

Phase III. Advanced interoperability demonstrations using US and UK COTS/OSA technologies. This will expand on the level of complexity in the type of scenario and interaction between the sensor and command aspects of the systems and investigate the task force implications. It will also address the integration of information into the scenario from other than naval sources and examine the increased level of complexity this will generate.

4. Background

4.1 *Scope and Nature of the Application Domain*

The naval combat system is a complex development challenge. The system typically incorporates extensive information processing capabilities. The electronics fills an attack center manned by numerous skilled console operators. The software runs to nearly ten million lines of code.

This extremely large man-machine system operates in real-time to transform data from thousands of sensor elements into information on which the attack center staff predicates decisions that effect ship control/maneuver, identification, classification and localization of contacts, and deployment of weapons and countermeasures. The system must operate effectively twenty-four hours a day for months at a time. It must be resilient in the face of attempts by outside forces to manipulate, confuse, and defeat it. It must be maintainable in situ by the crew that interacts with it. The most important time for it to operate with maximum efficiency is when it is completely overloaded. Obviously, operability is a major concern with a requirement for information display to operators to be highly intuitive so as to minimize reaction time and maximize optimal decision-making.

Because the combat system is so large, it must be subdivided into smaller parts to facilitate its development. Intellectual control over the development could not be attained without doing so. Also, the parallel development activity that results reduces the development cycle time. Experience has shown that the down side is a challenging

integration activity at the end of the development cycle where available funds and schedule are always most strained.

Because combat systems are so expensive, there is a need to construct them from already available modules or ones previously invested in. It is not feasible to throw the previous generation combat system away and start the new development from scratch every few years as appears to be the process in the commercial world. Thus, the notion of “reuse” of previously developed items and the adoption of COTS technology is particularly attractive.

Also, because combat systems are driven by the need to meet real time performance constraints, it is important to take advantage of rapid advances in hardware and software technology. To assure that performance goals are met, it is important to design the system in such a way that it readily admits the replacement of components with more advanced technology that provides performance gains. Thus the concept of an open architecture is of more than passing interest.

Because combat systems are mission critical in nature, it is important to assure that software (and hardware) modules are highly reliable from the moment of initial deployment. More testing breeds greater confidence in this regard. Exposing such components to a large user community, as is the case with COTS products, affords the opportunity for uncovering errors before critical deployment occurs.

It is clear that modular construction, open architecture, COTS technology, and re-use of available components are attractive notions as regards combat system development. In a real sense, the combat system is an interoperable system of subsystems. The most recent challenge for the naval platforms is to further require that these combat system as a whole interoperate with other fleet combat systems to prosecute battle force, joint, and/or coalition force missions.

4.2 *Interoperability and the Combat System*

In a development world centered on the reuse of COTS piece parts, the traditional definition of “development” becomes obsolete. Instead, the development activity becomes predominantly an integration and test activity. That integration and test activity is aimed at achieving an effective assemblage of linked subsystems that must interoperate effectively to provide a platform-level combat system capability. As has been noted, that platform-level combat system must also be capable of interoperation with other platform combat systems to achieve successful collaborative prosecution of battle force missions.

It is instructive to consider the source of the interoperability mandate. There are three seminal factors at play here. They are the reduction in defense budgets, the expansion of mission requirements, and the emergence of casualty avoidance as a priority in armed conflict. The reduction in defense budgets has resulted in a significant consolidation of defense industry and a significant reduction in the size of defense forces, thus reducing the marketplace for defense products. These, in turn have led to increasing partnership

(among corporate entities, between government and industry, and among the defense acquisition activities in allied countries) in developing such specialized products as combat systems. The expansion of mission requirements and the casualty avoidance mandate have contributed to a significant expansion of information needs. In the one case, new missions result in new information being needed to deal with previously unprecedented activities. In the other case, avoiding casualty means having information of such a precise nature that physical risk to combatants and non-combatants alike is minimized. The casualty avoidance strategy, coupled with the expanded information needs results in an increasing focus on information warfare as the first best way to fight. The fact that defense forces are smaller and yet require greater information assets means that coalition force operations are more and more the norm. The net result of all of this is that interoperability is a key performance objective for combat systems of all kinds.

It is clear that interoperability is a highly desirable attribute for a combat system. It is much less clear how to achieve interoperability goals through application of specific design guidelines. Intuitively, use of COTS products and open architecture are important to cost-effective achievement of interoperable systems. However, there is much confusion in defense acquisition circles over what the terms mean, much less how to achieve interoperability. Too many acquisition managers are ready to proclaim salvation from adoption of COTS-based development and/or OSA without really understanding the impact of their decisions in this regard.

Using COTS products does not make a system open. "Plug and play" is a marketeering slogan, not an engineering solution. Claims of inherently lower development cost from COTS application are appropriate only for those who believe in a free lunch. "Mass-market tested" means that some buyers with different needs from yours may have found some problems.

It may even be the case that COTS technology is in conflict with the mission critical environment. Military systems would certainly benefit from the ability to rapidly insert components with improved technology. Leading edge capability at the earliest moment is highly desirable. Therefore, rapid insertion of COTS technology supported by open system engineering of the combat system appears inherently beneficial. However, consider that the military environment demands assured, intuitive operability of the combat system. Commonality of user interface has a very high priority if operators are to do the optimal thing instinctively. But the very fact that there are competing products in the marketplace derives from their differences, not their commonality. If they did not have some claim to uniqueness they would have no place in the market. Thus, the diversity of implementations deriving from the COTS marketplace considerations poses operability risks in an open system environment. An important problem then is where to draw the line between *identity* which preserves operability and facilitates interoperability and supportability, and *diversity* which provides for the fastest availability of advanced capability, avoids obsolescence, and precludes vendor lock.

There are a number of other problems and weaknesses attending to COTS-based development and open architecture as well. Among these are:

- How to test and certify a system incorporating COTS components for which there is no design disclosure
- How to handle configuration management in a COTS environment where items with the same product model number may in fact incorporate different sub-elements with subtle performance differences
- How to compute the total ownership costs of COTS-intensive systems
- How to change budgeting paradigms to support the shorter technological refresh cycles and early obsolescence of COTS products
- How to provide fleet elements with a unified logistics support capability that embraces COTS products
- How to define objective measures of openness of architecture

5. TRDP Programme

The objectives of this TRDP is, through the design, implementation, integration and utilisation of a set of interconnected Open Systems Architecture Test beds, to:

- leverage US and UK technology insertion programs in support of combat system design for present and future operational platforms through mutual participation in planned test events and demonstrations;
- establish a capability for wide area network-based experimentation to address the evaluation of integrated Naval combat systems for effective coalition force operations at platform and task force levels;
- collect data on the facility with which commercial hardware and software technology components can be integrated with existing naval combat systems and new systems employing heterogeneous components;
- identify issues associated with the naval combat system data interchange at the command and sensor level; and
- evaluate, through experimental application, the effectiveness of advanced techniques and tools in support of the construction, acquisition, and through life upkeep of naval combat systems.

6. Support to TRDP

The TRDP provides the following benefits:

- The opportunity to advance interoperability between UK and US platforms which is a known problem area with the current fleets.
- The opportunity to investigate the differences in the UK and US Naval operational doctrine, and areas of known differences which can affect the take up of common technologies and affect operations, and propose methods by which interoperability can be achieved.
- The opportunity to identify areas of research where information can be pooled and then used to conduct joint operations, since it is easier to identify areas of the potential for research collaboration when there is a key focus.

- The chance to investigate the information which needs to be exchanged between the different surface and subsurface and US/UK platforms to achieve interoperability without causing overload to the networks, the systems at either end, and most importantly the operator.

The following have been identified as potential areas for collaborative experimentation:

- interoperability between surface and subsurface platforms
- impact of exchanging information between surface and subsurface on a spasmodic basis;
- sensor triangulation;
- force data fusion
- remote use of sensors
- Measures of effectiveness for joint/coalition forces.

7. Initial experiments

As indicated by the Phase 1 description the first task will be to set up the basic communications link and identify the commercial technology that is available to support the exchange of combat system data. There is every reason to believe that while there are claims made by industry that they have the technology there will need to be a considerable amount of effort spent in producing an effective communication network with the necessary levels of reliability in all areas. This will form the base for future work and will be used to resolve all the issues associated with the ‘understanding’ of the data which is exchanged. It will need to investigate the format and structure of information, the information architecture, and allow both sides to reach an agreement on their interpretation of that information within their own environment. There is no point in exchanging data that is not useful and the early tests will need to identify the basic levels that are acceptable by the two systems in terms of enhancing the system capability with the introduction of new information but at the same time not overloading it with useless data. There will be several tests over the first period of the TRDP culminating in a demonstration of the basic capability to exchange combat system information on a common scenario synchronised between the two sites. It will also demonstrate the management and control software that will be needed to support the running and monitoring of future experiments.

7.1 *Interoperability between Surface and Subsurface Platforms*

In a more general subject area, it will be necessary to investigate the relationship between a subsurface platform and surface platform and the transfer of information between them. It will be necessary to investigate the use of current datalinks (11 and 16) or other message formats and to consider whether the present operational procedures are acceptable in the new network centric environment. It might be an appropriate time to consider how best to handle the coalition force information in this situation as distinct

from the present data link scenarios. Although existing L11 and L16 include some subsurface message formats they have been used little to date

As has been indicated above the first set of experiments will involve achieving basic synchronisation and interoperability between the two systems this will lead onto the more network centric aspects of the coalition force environment.

Large scale information transfer involving submarines is likely to be performed on a spasmodic basis, enabled only when a submarine is in contact with a surface platform. The purpose of this area of research is to determine:

- The effect on the above water platform of integrating such spasmodic and time varying information from a submarine into the rest of its tactical picture involving organic and non organic wide area non real time information.
- The effect on the under water platform of integrating real time information into its picture and subsequent handling of that data in terms of staleness, predictions etc.

This will build on the previous set of experiments which will have identified the types of information that could be exchanged and how this could be managed. The aim at this stage will be to compare the pictures compiled in the relevant surface and subsurface platforms particularly as time progresses without refresh, to determine whether the degree of drift between the actual and perceived positions outweighs the initial transfer of information and whether better staleness or prediction measures could be used to improve the pictures. It will also allow some assessment of the best options for interoperation between the surface and subsurface platforms in terms of the procedures covering such aspects as frequency of contact and amount of data exchanged.

7.2 *Sensor Triangulation*

As an example of the type of problem in the sensor domain the area of sonar triangulation would involve the use of the CSI test bed as a future UK surface platform with say only a passive sonar capability and the NUWC WAIF as the US subsurface platform with both active and passive sonar. The aim will be to investigate sonar triangulation between the sonar data from the surface and subsurface platforms initially using techniques developed for EW.

The first part of the task will be to determine what associated research is available within the UK and the US including:

- above water passive EW triangulation techniques
- land EW techniques.
- underwater passive techniques.

It will then be necessary to determine the level of information to be passed between the surface and subsurface domains to perform the necessary calculations depending on the chosen methods to be investigated. The foundations for this will have been set during the earlier information architecture investigations.

The first part of the experiment will be to exchange information between the UK surface and US subsurface pictures including:

- synchronisation data to allow time and grid synchronisation to be achieved;
- basic tactical picture data particularly surface platforms in the scenario which can be used correlate the above and underwater pictures.
- the agreed passive sonar information;

Once the basic exchange of messages is achieved then a sonar triangulation trial can be performed. Experiments will then be carried out to widen the scope of the sensors being considered and to identify how best to utilise the data available from both 'platform' test beds

This will form the basis for the next main area of research which will be addressing the data fusion and picture generation in a coalition task force environment.

7.3 *Force Data Fusion*

Once the US network has been extended to link to other US surface platform testbed facilities and the UK end has a similar extended capability, issues such as force data fusion across the coalition surface and subsurface platforms can be investigated. This opens up the possibility for investigating:

- The different operating characteristics of the UK and US navies,
- The different data fusion methods employed,
- The opportunity to exchange sensor data information at all levels,

It will also provide the ability to investigate the remote use of sensors and weapons such as EW, sonar, torpedoes and missiles between coalition platforms, initially starting with the sub to surface link and then expanding to the different platforms in the network. The network at this stage should be capable of allowing land and air platforms to be integrated as part of the environment and the full coalition battle space scenario addressed, building on the experience gained from the earlier investigations and experiments.

8. *Effectiveness of Collaboration*

In parallel with the research identified above, a major activity during this work must be the identification of measures of effectiveness for coalition force activities. While it may be possible to exchange information it is essential that there is some means of assessing the effectiveness of what is being achieved. This will need to take into consideration both the national and coalition requirements and to what level the coalition platform systems will be integrated into a task force unit. It will of necessity not only address the technical issues but will have to deal with the command and doctrinal issues which will arise.

9. Summary and the Way Ahead

The adoption of an early integration testing approach in the development of complex systems has proven to be a success. In fact, the U. S. Navy has since embarked on the establishment of a Distributed Engineering Plant (DEP) and a Collaborative Engineering Environment (CEE) modeled on their Wide Area Integration Facility (WAIF) experiences. From an architectural perspective, the development issues and the operational issues are seen to have much in common where test and integration are concerned. This approach is now being employed at the joint/coalition force level and the avoidance of operational problems achievable as a result of adopting such an approach is substantial.

Taken in its broadest view, interoperability is more than just connectivity and communications. Its import goes beyond just command and planning activities to embrace real time sensor data integration among collaborating platforms. The drive for interoperable combat systems is a natural consequence of the increasing emphasis on information warfare, of the increasing reliance on joint and coalition forces to achieve military objectives, of the increasing reliance on commercial technologies, and on the decreasing defense acquisition and research and development budgets. Needing or desiring interoperability is not the same as achieving it however. There remains much to do to bring about the interoperable combat systems needed for success in the era of network-centric operations and information warfare.

As we seek to manage an information landscape that is more comprehensive and diverse each day, it is important to guard against the technological imperative to do things merely because we can. Access to all information all of the time is not the optimal design objective for combat systems. It is not even desirable. We must also guard against the tendency to confuse technology with engineering. Proper use of technology requires that we engineer our systems with careful attention to architectural issues. There remains plenty of work to do. A near-term list might include:

- Identifying the consequences of interfacing systems designed to different architectural standards

- Developing measures of architectural openness

- Overcoming obstacles to wide-area distribution of time critical sensor-to-shooter loops

- Determining the extent of necessary commonality in deployed information infrastructure

- Understanding and coping with terminological and training barriers to interoperable coalition force combat systems

- Identification of an appropriate Combat System Interface Profile to support interoperability

- Developing criteria for managing the information landscape

The bottom line objective in the search for combat systems that are both operable and interoperable must never be lost sight of: providing the right amount of the right information to the right place at the right time in the right format.